
Appendix B: Lead Shot Alternatives

Another method of preventing lead contamination at pistol, rifle, trap, skeet, or sporting clays ranges is to use less toxic or non-lead ammunition.

Much progress has been made in the development of alternatives to lead shot for hunting uses. Information gathered since 1976 on lead poisoning of endangered and non-endangered migratory birds due to lead shot ingestion, led the United States Fish and Wildlife Service (USFWS) to consider several alternatives to eliminate lead poisoning among migratory waterfowl birds. A ban on lead shot for water fowl hunting was phased-in beginning in 1986, and finalized in 1991. Lead shot is also now banned for shotgun hunting occurring near wetlands in national wildlife refuges. Starting in the fall of 1998, the USFWS banned the use of lead shot in waterfowl production areas. Additionally, many state-managed hunting areas require non-toxic shot for upland/small game hunting.

There are several alternatives to lead shot on the market today and still more alternatives are being developed. Before being used for waterfowl hunting, these alternatives must be approved by the USFWS. Bismuth, steel, tungsten/iron, and tungsten/polymer shots have been approved by the USFWS and additional other alternative shot materials are in the USFWS approval process. Most of the ammunition manufacturers in the United States, as well as the military, have developed non-toxic alternatives to lead. Research in Europe may also result in additional non-toxic shot alternatives from which U.S. shooters may choose in the future. The following pages compare lead shot to non-toxic, alternative shot.

Summary of Lead Shot Alternatives[†]

Shot Material	Approximate Cost per 25 Round Box ¹	Ballistic Performance	Availability	Comments
Lead	\$5.00/box \$3.00 - \$4.00/box of reloaded shells	Standard to which all alternatives are compared	Readily available	Lead is heavy and malleable
Bismuth* 97% Bismuth/ 3% tin	\$37.50 - \$62.50 (bismuth shells are packed in 10 round boxes @ \$15.00 - \$25.00/ 10 round box) \$2.00/shell	Similar to lead	Limited world supply of bismuth	Bismuth is a by-product of lead and gold mining. There are currently many uses, including: medicine (Pepto-Bismol), cosmetics, pigments and shotgun shot. The addition of tin makes bismuth more malleable and reduces frangibility. Bismuth shot is safe to use in older firearms.

[†] Product reference within this table is not an endorsement by EPA.

* Approved by USFWS for migratory waterfowl hunting.

¹ Costs will vary from store to store and were valid at the time of manual development.

Summary of Lead Shot Alternatives – Continued[†]

Shot Material	Approximate Cost per 25 Round Box ¹	Ballistic Performance	Availability	Comments
Steel [*]	<p>\$8.00 - \$12.95/box</p> <p>\$6.00/box of reloaded shells</p> <p>\$15.00/box (copper-plated)</p>	In test performance by the Cooperative North American Shotgun Education Program (CONSEP) in hunting situations, no significant differences were found between lead and steel shot at resonable ranges. Lead is more effective at longer ranges.	Readily available from both domestic and imported sources.	<p>Steel shot is about 33% lighter than lead. Therefore, the initial velocity must be increased so that downrange pellet energy remains similar. In hunting situations, larger, and therefore heavier, steel shot is used. Few shooting competitions allow steel shot at this point, but the number is increasing.</p> <p>While steel target loads are available, shooter perception that steel will adversely affect guns and scoring seems to be the limiting factor in acceptance of steel shot for target shooting.</p> <p>Steel shot will not damage newer guns, but may cause ring bulge in older guns if a very tight choke is used. This problem as been resolved in the newer guns with the use of screw-in chokes.</p>

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Summary of Lead Shot Alternatives – Continued[†]

Shot Material	Approximate Cost per 25 Round Box ¹	Ballistic Performance	Availability	Comments
Steel [*]				<p>Another concern with steel shot is safety. Because steel is much less malleable than lead, steel shot is likely to ricochet if it strikes something hard. Lead shot, on the otherhand, will deform and flatten. In Europe, steel shot is banned for hunting because it can become embedded in trees. The steel shot in trees cut for lumber can cause damage to sawmill equipment and raise concerns about worker safety.</p> <p>Although steel shot can be reloaded, components are not readily available.</p>
Tungsten/Iron [*] 40% tungsten/ 60% iron	\$62.50/box (tungsten/iron shots are packed in 10 round boxes @ \$25.00/10 round box)	Preliminary reports indicate that tungsten/iron shot is as effective as lead shot. However, the amount of shot in each cartridge is significantly less than in typical lead cartridges or even steel cartridges. The density of tungsten/iron is 94% that of lead.	Readily available	The tungsten/iron shot currently available is harder than steel. It would, therefore, cause similar damage to older guns.

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Summary of Lead Shot Alternatives – Continued[†]

Shot Material	Approximate Cost per 25 Round Box ¹	Ballistic Performance	Availability	Comments
Tungsten/polymer Various manufacturers have received final approval from the USFWS to this type of shot.	Not available yet	Comparable to tungsten/iron	Currently not available	Two ammunition manufactures are currently producing tungsten/polymer shot. This shot is more malleable than the tungsten/iron alloy, and would, therefore, be less damaging to shotguns. A research and development company has developed a tungsten/polymer material as a substitute for lead in all its uses. Accordingly, to this company, its tungsten/polymer can be formulated to be flexible or stiff depending on the application. This material has been tested by the US Army in projectiles, but has not been used to manufacture shot. However, the company has initiated the process of applying to the USFWS for approval of this material as non-toxic shot.

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¹ Costs will vary from store to store and were valid at the time of manual development.

Summary of Lead Shot Alternative – Continued[†]

Shot Material	Approximate Cost per 25 Round Box [†]	Ballistic Performance	Availability	Comments
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Other materials that are currently being experimented with as alternatives to lead are molybdenum and zinc. Not enough information is available to have included these alternatives in the above table.

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The table clearly illustrates that a number of non-toxic alternatives to lead shot exist such as steel and tungsten as well as alloys and synthetic polymers. As demand for shot from these metals increases from migratory waterfowl hunters, it is anticipated that the costs will come down. However, alternatives currently cost approximately two to twenty times more than lead shot.

The ban on lead shot in hunting situations impacts target shooting. The alternatives to lead shot that are now being developed for or are already approved by the USFWS for migratory bird hunting could be considered for use by target shooters.

Although alternatives to lead shot are now being used by hunters, it is rare that the alternatives are used by target shooters. The limiting factors appear to be the expense and performance. All the alternatives to lead are much more expensive, some prohibitively. Unfortunately, the least expensive alternative, steel, is also perceived to be less effective.

To encourage use of lead shot alternatives, some ranges sponsor shooting competitions using lead-free ammunition, but these are rare. Promoting steel shot as the “marksman’s ammunition” may encourage greater use of that type of shot. The use of steel or other alternative shot is a recommended BMP in established sporting clays areas at which reclamation of lead shot is difficult to impossible.

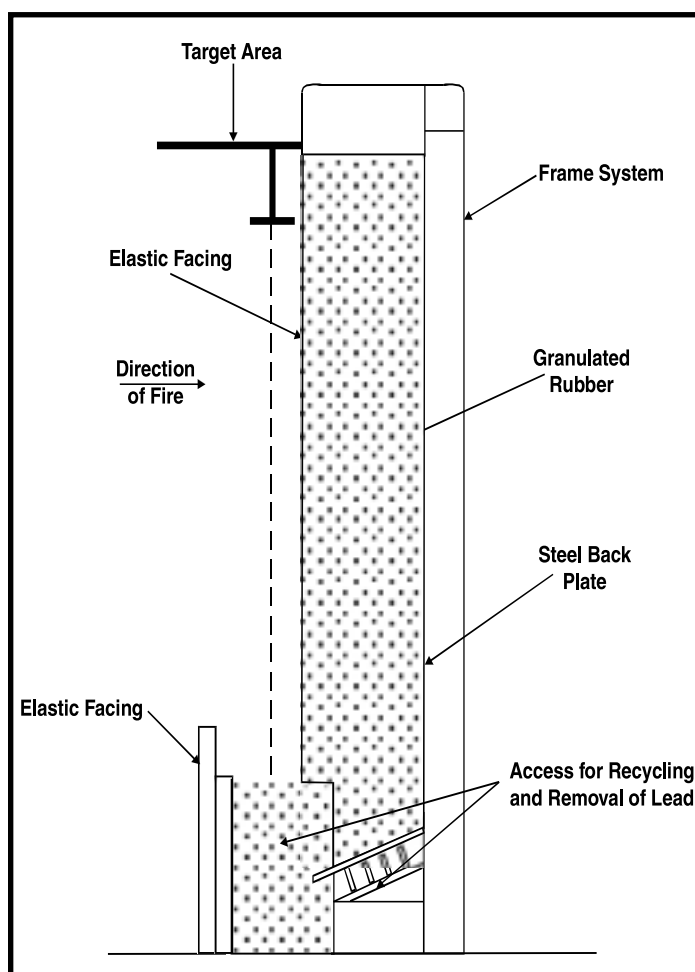
Note: Switching to non-toxic shot may create additional issues. For instance, steel has an increased risk of ricochet. Switching to steel may require additional safety features and/or operating procedures.

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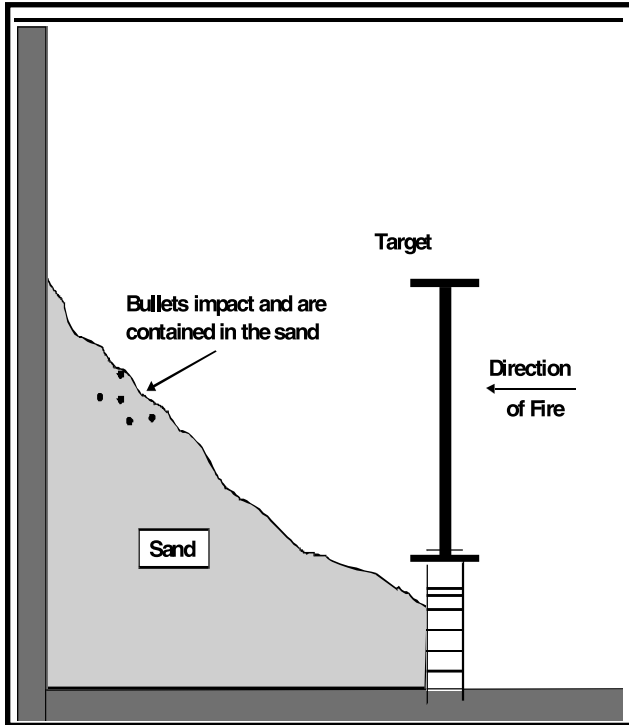


Appendix C: Sample Bullet Containment Devices

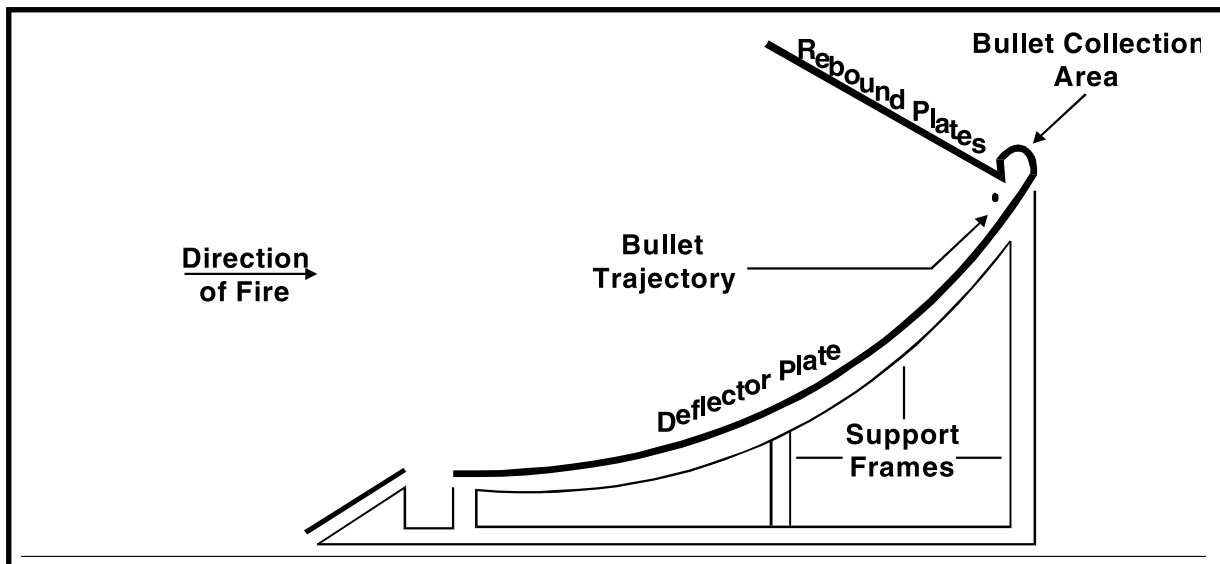
The bullet containment designs in this appendix are sample designs for the containment systems mentioned in this manual. Design systems may vary from different manufacturers. Reference to various individual bullet containment devices is included in this manual for informational purposes only. EPA does not endorse any particular bullet containment device, design, or product.



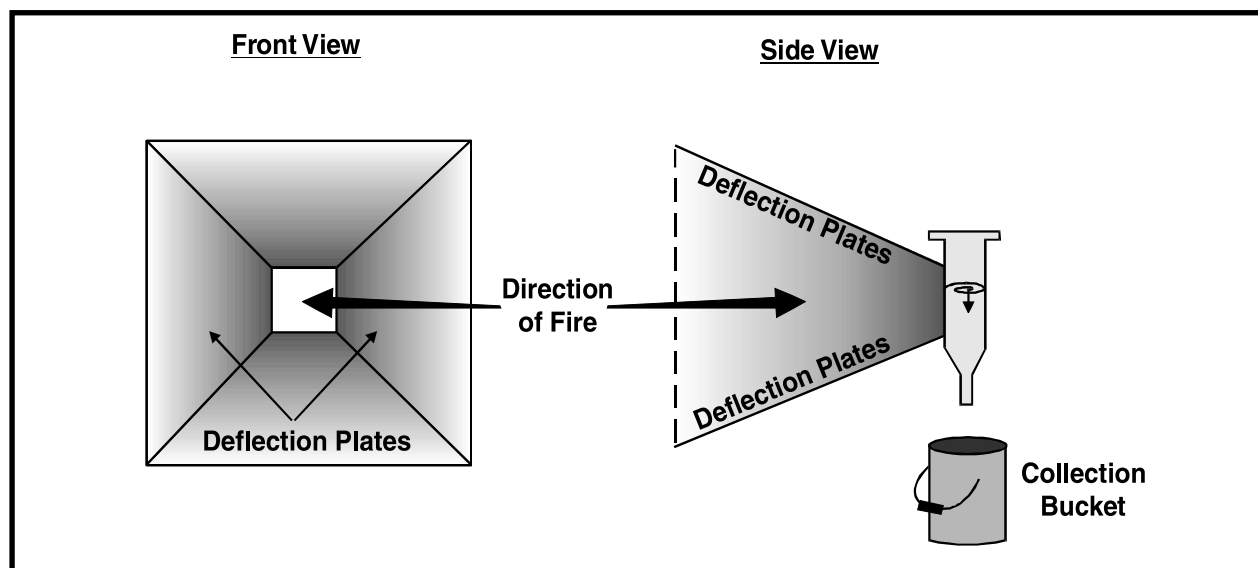
Rubber Granule Trap (Adapted from: *Bullet Trap Feasibility Assessment and Implementation Plan: Technology Identification Final Report*, U.S. Army Environmental Center, March 1996)



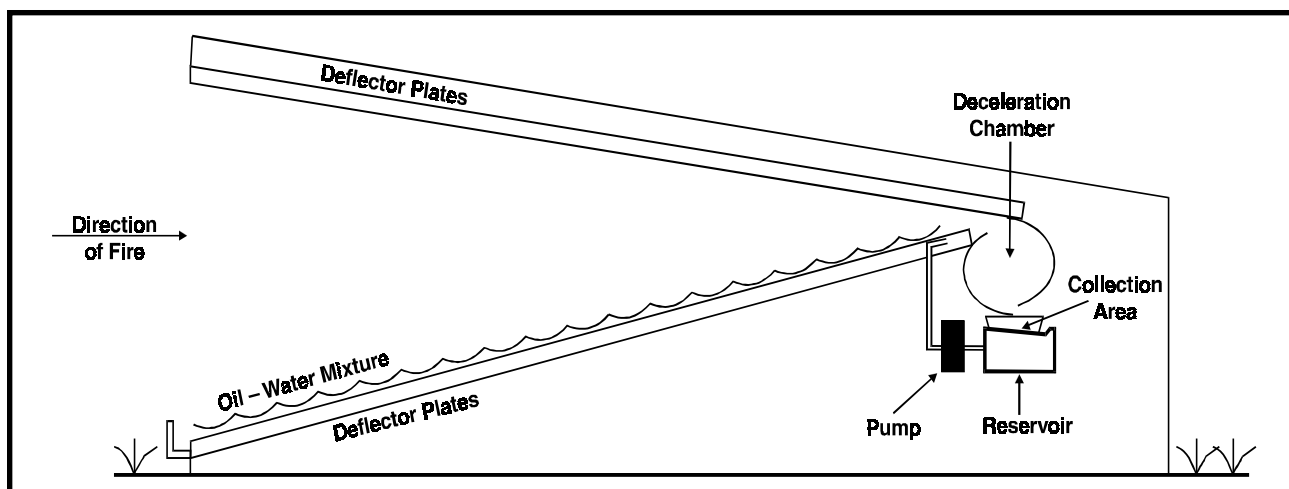
Sand Trap



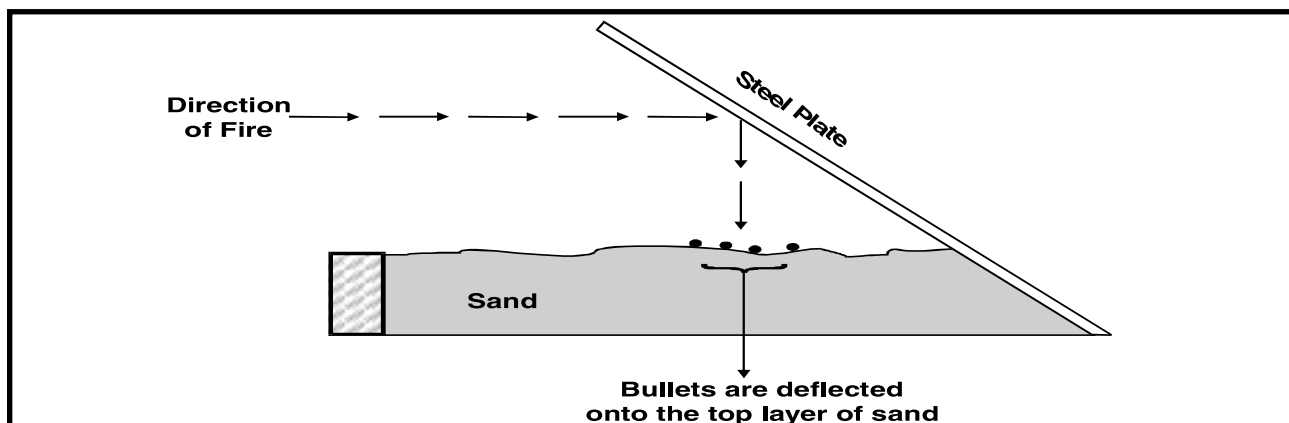
Escalator Trap (Adapted from: *Bullet Trap Technologies*, Action Target Educational Video Series)



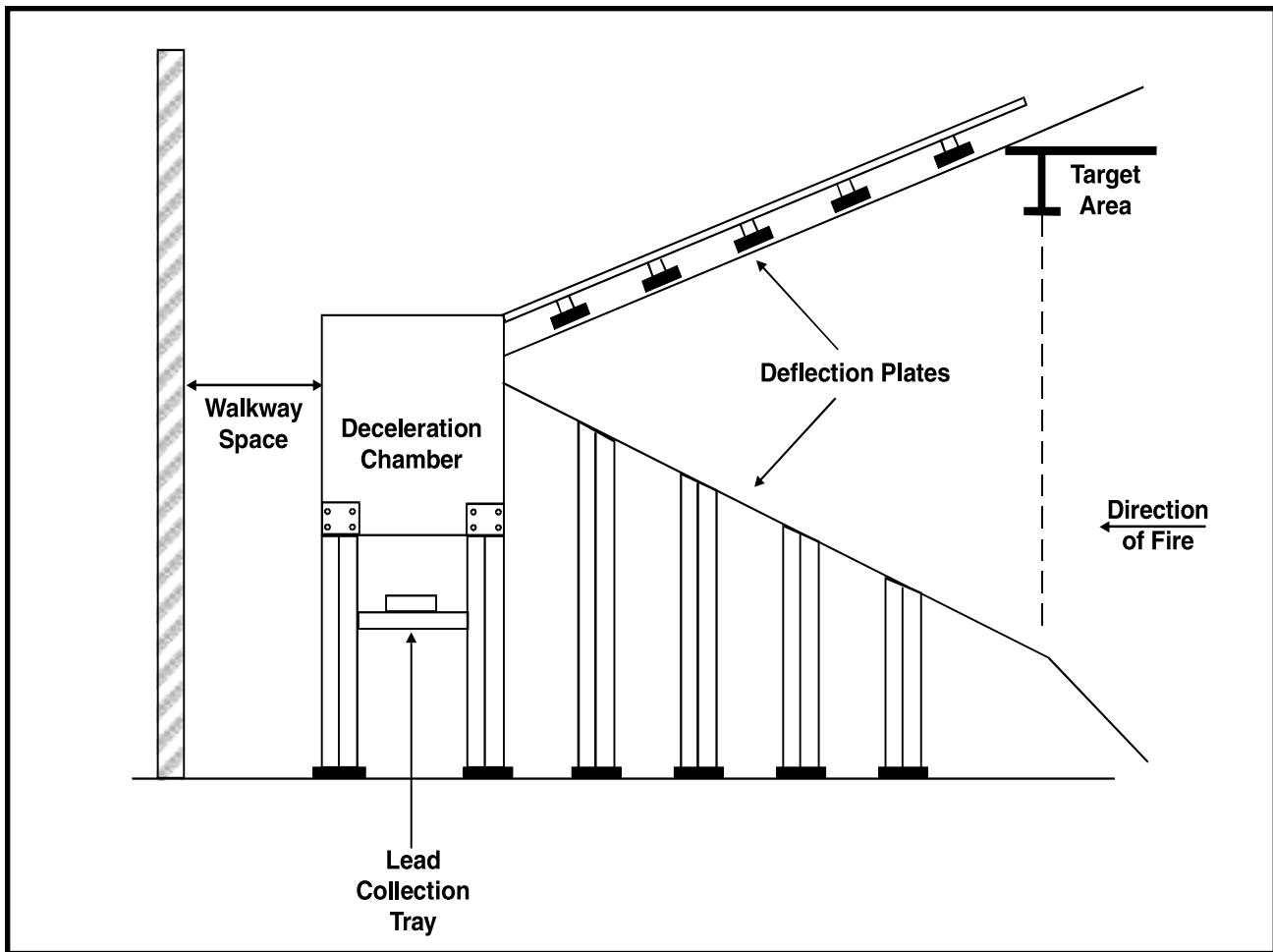
Vertical Swirl Trap (Adapted from: *Bullet Trap Feasibility Assessment and Implementation Plan: Technology Identification Final Report*, U.S. Army Environmental Center, March 1996)



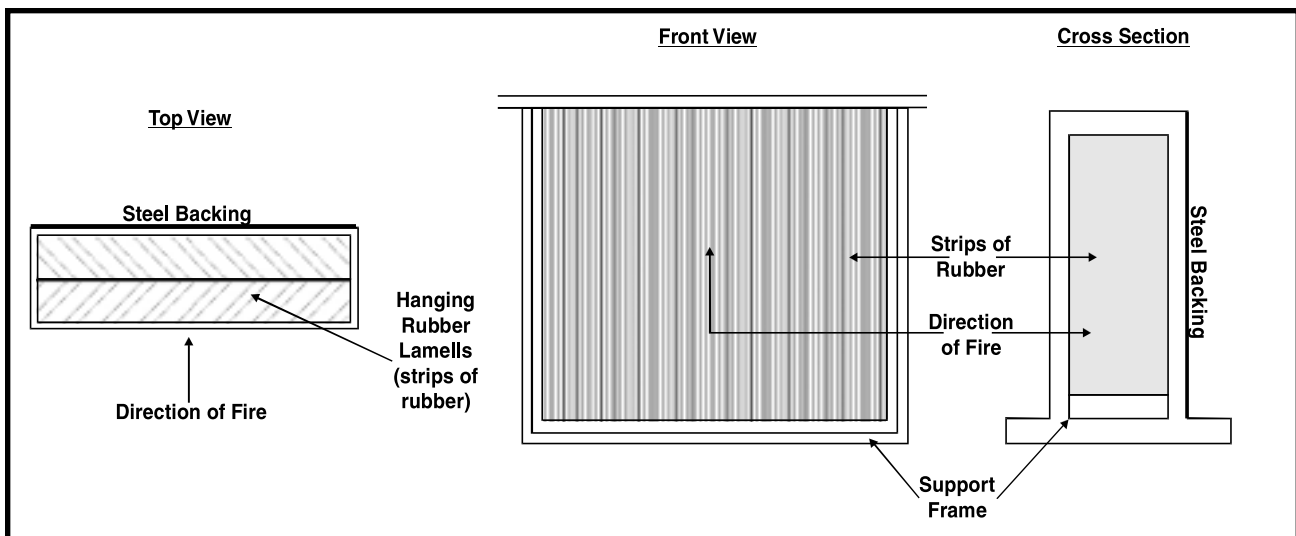
Wet Passive Trap (Adapted from: *Bullet Trap Feasibility Assessment and Implementation Plan: Technology Identification Final Report*, U.S. Army Environmental Center, March 1996)



Pitt and Plate (Adapted from: *Bullet Trap Feasibility Assessment and Implementation Plan: Technology Identification Final Report*, U.S. Army Environmental Center, March 1996)



Steel Bullet Trap (Adapted from: *Bullet Trap Technologies*, Action Target Educational Video Series)



Lamella Trap (Adapted from: *Bullet Trap Feasibility Assessment and Implementation Plan: Technology Identification Final Report*, U.S. Army Environmental Center, March 1996)